GRAPHICAL INPUT CONTROLLER AND METHOD WITH REAR SCREEN IMAGE DETECTION

REFERENCE TO ORIGINAL APPLICATION

This application is a continuation-in-part of patent application Ser. No. 07/837,371 filed Feb. 14, 1992 now abandoned.

BACKGROUND OF THE INVENTION

1. Field

The present invention relates to the field of graphical input devices for interactive computer graphics. More specifically, the present invention relates to the rear screen video detection of multiple objects, such as fingers, on a semi-transparent touch screen used to control interactive computer graphics.

2. Art Background

Broadly, graphical input devices for interactive computer graphics sense the actions of a user. Most such graphical input devices are manipulated by the user. These include the devices commonly associated with personal computers, such as light pens, mice, joysticks, track balls, and keyboards. However, there are also a number of devices that directly sense the actions of a user. Touchscreens with sensors in the display screen are one example of such devices. Myron W. Krueger discloses a number of other devices in his book *Artificial Reality II,* 1991, that use video cameras to detect the position of a user's hand or body in free space. The VIDEODESK concept described in Krueger's book is also described in U.S. Pat. No. 4,843,568, titled Real Time Perception of and Response to the Actions of an Unencumbered Participant/User, issued to Myron W. Krueger, Katrin Hinrichsen and Thomas S. Glonfriddo Jun. 27, 1989. However, this device requires the user to place his hands on a backlit screen mounted on the upper surface of a desk within the view of an overhead video camera and requires the camera's view of the hands to be unimpeded. As a result, the controller is burdensome and bulky.

The drawing prism presented by Richard Greene at the 1985 SIGGRAPH in San Francisco uses a large transparent prism as a drawing surface. As described in *"The Drawing Prism: A versatile Graphic Input Device,"* Richard Greene, ACM Volume 19, Number 3, 1985, pages 103–110, and in U.S. Pat. No. 4,561,017, titled Graphic Input Apparatus, issued Dec. 24, 1985, , a video camera is arranged to view that surface from an angle such that it can only image the points of optical contact between drawing tools and the surface. However, this device is based on the refraction and total internal reflection of light at a dielectric surface and requires rather precise and expensive optical components and alignment.

Another camera-based system is the Sensor Frame of Sensor Frame Corporation. The Sensor Frame controller uses multiple cameras with intersecting fields-of-view to detect multiple light-occluding objects within a frame. This device is described in U.S. Pat. No. 4,746,770 titled Method and Apparatus for Isolating and Manipulating Graphics Objects on Computer Video Monitor, issued to Paul McAvinney on May 24, 1988. This apparatus is capable of simultaneously detecting the positions of multiple fingers. However, it requires multiple cameras to detect the positions of objects. Further, the device has certain problems with "ghost" images when multiple objects are detected.

It is desirable to provide a graphics input device that provides free-form inputs, commonly referred to as gestures, which directly senses the actions of a user without impeding or otherwise restricting a user by requiring him to wear or hold a device. It is further desirable that the device can sense simultaneous multiple inputs. Further, it is desirable to provide such a system that reduces the requirements of image processing so that it can be implemented real-time on a commonly available computer system. Finally, it is desirable to provide a system that can provide an input suitable for controlling a multi-dimensional application, such as a three-dimensional graphics application.

SUMMARY OF THE INVENTION

A graphics system in accordance with the preferred embodiment of the invention includes one or more semi-transparent screens with a rear mounted video camera. The camera is arranged to detect the shadows of objects, such as fingers, touching the screens. These shadows are referred to as "touch points." This provides for a simple two-dimensional input image, which greatly simplifies the image processing required. Specifically, as the camera is only required to detect the existence of shadows on the screens, only a two-dimensional image needs to be processed. Further, as the light/dark areas are easily differentiated, image processing is further simplified. The graphics system also provides an unimpeded environment for the user. The camera is used to detect multiple touch points resulting from the touch of multiple fingers on the screens. This provides for the input of a multiplicity of gesture commands. As a result, a practical, convenient and intuitive system is provided that can directly sense multiple finger touches and gestures without placing any restrictions on the users actions. Finally, force-sensitive sensors are used to mount the screens to the enclosure so as to sense forces applied to the screens and to provide an alternative "z" input capability for use in moving and manipulating display objects.

These and other advantages and features of the invention will become readily apparent to those skilled in the art after reading the following detailed description of the preferred embodiment of the present invention and studying the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a rear-screen video graphics input controller having and an interactive computer graphics system including a display in accordance with the preferred embodiment of the invention.

FIG. **2** is a perspective view of an alternative graphics input controller having multiple rear-screen video control surfaces and a interactive computer graphics system including a display.

FIG. **3** illustrates the image space, or the image captured by the CCD camera of FIG. **2**,

FIGS. **4***a–c* illustrate control gestures on the controller of FIG. **2** and the resulting displays on the display of FIG. **2**,

FIG. **5** is a flow chart illustrating the steps in the processing of the images obtained by the CCD camera of FIG. **2**,

FIG. **6** provides a functional block diagram of the system of FIG. **2**,

FIG. **7***a–7d* illustrates the steps of FIG. **5** in a image format.